Chapter 12
Conceptual Mapping Facilitates Coherence and Critical Thinking in the Science Education System

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EXECUTIVE SUMMARY

In this case, the authors propose a pathway of visual mapping through which the science education system from professional educators who produce representations of national and state standards to curriculum coordinators at the school district level to individual teachers and students in the classroom could be aligned in order to promote meaningful learning of a connected set of concepts. Conceptual mapping is demonstrated to be a tool that promotes critical thinking, cohesion, and meaningful learning in opposition to the learning of arbitrary facts and rote memorization. The authors offer many examples of conceptual maps that have been produced to externalize thinking at each level. This chapter provides a "synthesis case" demonstrating that not only does it require critical thinking to create conceptual maps, but, equally salient, these visual representations of our thinking catalyze further critical thinking and coherence within the science education system.

BACKGROUND: CRITICAL THINKING, MEANINGFUL LEARNING, CONCEPTUAL MAPS, AND THE SCIENCE EDUCATION SYSTEM

Critical Thinking and Concept Mapping

A host of researchers have linked constructing concept maps (cmaps) with critical thinking (Jonassen et al., 1998; von der Heidt, 2011; Fonseca & Extremina, 2008.) As the chapters in this book will make abundantly clear, "critical thinking" has been defined different ways by different authors. Further, Krathwohl (2002) recognized the terms 'critical thinking' and 'problem solving' lacked clarity of meaning in popular usage and advised that "one must determine the specific meaning of 'problem solving' and 'critical thinking' from the context in which they are being used." A clear articulation of the relationship between cmapping and critical thinking comes from the field of nursing education. Daley et al. (1999) turned to a Delphi research project of the American Philosophical Association (APA) (1990), which published a consensus definition of 'critical thinking' based on the views of 46 published critical-thinking theorists from numerous disciplines. This definition states: "Critical thinking is the process of purposeful, self-regulatory judgment. This process gives reasoned consideration to evidence, contexts, conceptualizations, methods, and criteria" (APA, 1990, p. 2). She continues with Facione (1995) "Like many other descriptions of higher order thinking, the original Delphi authors conceptualized a simultaneous, metacognitive, self-appraisal of one's thinking process (that is, thinking about and evaluating one's thinking while engaged in the process of purposeful judgment (p.2). Drawing the connections clearly to the cmapping process, Daley concludes: Cmaps. . . link directly to the APA (1990) definition of critical thinking. Cmaps are metacognitive tools that assist learners to develop a self-appraisal of their own individual thinking processes. The maps foster a careful consideration of evidence drawn from clinical practice. Through use of cmaps, learners develop the ability to consider the context of nursing practice in their conceptualization of client problems. Finally, purposeful judgments are made regarding interventions based on how methods and criteria are linked to the conceptualization of the problems." Chabeli (2010) sinks deeper, providing a table correlating core cognitive critical thinking skills, related subskills and affective dispositions with the educational processes of cmapping.

In his literature review pertaining to the use of cmapping techniques and technologies for education and performance support, A. Cañas (2003), listed "to teach critical thinking" along with a variety of uses of cmaps. Novak and Cañas (2008) further explain, that the creation of cmaps clarifies a growing conceptual framework